OSC015 - ALGEBRA-BASED PHYSICS II (WITH LABS)

4-5 Semester Hours

Co-requisites: College Algebra and Pre-calculus.

Related TAGs: Chemistry, Civil/Construction Engineering Technology, Electrical Engineering Technology, Mechanical Engineering Technology

Required Components include:

- **I. Experiment**
- **II. Electromagnetism**
- **III. Electrical Devices and Circuits**
- **IV. Geometric and Physical Optics**

Optional Components include:

- **V. Special Relativity**
- **VI. Quantum Physics**
- **VII. Nuclear Physics**

In order for a course to be approved for OSC0015- Algebra Based Physics II (with labs), all of the following must be met:

1) All "Required Component" student learning outcomes (SLOs) 1-4 must be met and **at least one out of the three** "Optional Component" SLO's 5-7 **must be met**.
2) All student learning outcomes (SLOs) embedded within a "Required Component" area are required to meet the entirety of the core component area. This is also true for the "Optional Component" SLO's. All SLO's embedded within the optional component are required to meet the entirety of the optional component area however, this is only true when an optional component area is selected by an institution.

Required Components

1. **Experiment**:
   The successful Algebra-Based Physics II (with lab) student will be able to:

   1a. Collect data, assess its validity, and interpret its physical meaning for experiments that relate to the topics included in the required learning outcomes in required components 1-4 in OSC 015.

   1b. Meet the guidelines for the Natural Sciences Laboratory Requirement for the Ohio Transfer 36, found at the following link here.

Sample tasks

- Demonstrate an understanding of how to write lab reports including data-supported conclusions.
- Represent and analyze data in various forms (e.g., graphs, tables), as well as recognize trends and patterns in data accounting for scatter and outliers.

- Implement and design basic experimental procedures including the choice, variation and control of variables, as well as recognize the existence of uncertainty and an estimate of the precision of the measurements.
- Analyze data through the use of various mathematical approaches including vector manipulation and analysis, trigonometry, and algebra.
- Validate physics models and principles through collection of real physical data obtained by hands-on measurement.
- Recognize group work is a preferred environment.

2. **Electromagnetism:**

The successful Algebra-Based Physics II (with lab) student will be able to:

2a. Describe the motion of charged particles in external electric fields in terms of forces and energy.
2b. Describe electric fields and electrostatic potentials produced by simple charge distributions [point charges, charged plates, and parallel-plate capacitors].
2c. Relate the electrostatic energy stored in a capacitor to the energy density of the electric field.
2d. Relate electric field lines to equipotential lines.
2e. Describe the motion of charged particles and current-carrying wire segments in uniform magnetic fields in terms of forces and torques.
2f. Describe the magnetic field produced by current-carrying long thin wires and solenoids.
2g. Describe the motion of charged particles in regions with both electric and magnetic fields.
2h. Relate the magnetostatic energy stored in a solenoid to the energy density of the magnetic field.
2i. Relate the electric field lines to equipotential lines for simple charge distributions.
2j. Describe magnetic field lines for simple situations [wire, bar magnet, and solenoid].

Sample tasks

- Calculate the force on a point charge and its electrostatic potential energy due to one or more point charges.
- Calculate the force on an electric dipole and its electrostatic potential energy due to an external electric field.
- Calculate the electric field and electrostatic potential due to a simple distribution of electric charges [such as ions, dipoles, etc.].
- Draw electric field vectors from electric field lines or equipotential lines.
- Describe interaction between two charged particles as an elastic collision and calculate their velocities after the ‘collision’ from the velocities before the ‘collision.’
- Calculate the force between two plates of a charged parallel-plate capacitor.
- Use the description of charged particle inside a parallel-plate capacitor in 1d and 2d to find the charge on the capacitor.
- Calculate the electric field from differences in the electrostatic potential.
- Draw equipotential lines from electric field lines and *vice versa.*
- Calculate the force between two long current-carrying wires.
- Calculate the magnetic field due to several long-time wires.
- Calculate the radius of the circular trajectory of an ion in a mass spectrometer and analyze the dependence of the mass of the ion.

3. **Electrical Devices and Circuits**:

The successful Algebra-Based Physics II (with lab) student will be able to:

3a. Analyze the voltage drops across and charges on capacitors of a circuit of capacitors arranged in series and parallel.
3b. Analyze the voltage drops across and currents through resistors of a circuit of resistors arranged in series and parallel.
3c. Apply Kirchhoff's laws to find currents (in magnitude and direction) of multi-loop circuits with multiple batteries.
3d. Describe the powers delivered by batteries and the powers dissipated in resistors in simple circuits.
3e. Describe the time-dependence of the voltage and current through a resistor *R*, capacitor *C*, and an inductor *L*.

Sample tasks

- Find the equivalent capacitance of a system of capacitors partially connected in series and parallel.
- Find the equivalent resistance of a system of resistors partially connected in series and parallel.
- Solve a system of equations to determine the currents through circuits with two or more loops consisting of batteries and resistors using Kirchhoff's laws.
- Determine the power dissipated in resistors and the power delivered by batteries in a multi-loop circuit.
- Relate the exponential time-dependence of the voltage and charge on the capacitor in a RC circuit to the time constant.
- Characterize the oscillatory time-dependence of the voltage and current in a LC circuit.
- Describe the oscillation of electric and magnetic energy in a LC circuit.
- Explain phasor diagrams for RC-, RL-, and RCL circuits.
- Relate the power delivered by an AC generator in terms of rms values of voltage and current and the phase.

4. **Geometric and Physical Optics:**
The successful Algebra-Based Physics II (with lab) student will be able to:

4a. Describe light as an electromagnetic wave in terms of frequency, wavelength, and speed of light.
4b. Characterize the spectrum of EM waves in terms of frequency and wavelength.
4c. Describe the speed of light in matter in terms of index of refraction.
4d. Describe the refraction of light at interfaces and relate the angles of incoming and refracted rays in terms of Snells' law.
4e. Explain the dispersion of light by the frequency dependence of the index of refraction.
4f. Describe the intensity of EM waves in terms of electric and magnetic energy densities and the speed of light.
4g. Analyze the image formed by plane and spherical mirrors using ray tracing and the mirror and magnification equations.
4h. Analyze the image formed by one and two lenses using ray tracing and the lens and magnification equations.
4i. Relate the interference pattern of a double slit to the separation of slits and wavelength.
4j. Relate the resolving power of a lens to the diffraction of light by an opening.

Sample tasks

- Use Snell's law to find the apparent depth of an object below a surface.
- Determine the critical angle of a prism immersed in water.
- Explain everyday optical phenomena [mirages and apparent sun near the horizon] in terms of rays.
- Explain why white light separates into a rainbow of colors when it passes through a prism.
- Given the focal length of a thin lens and the object distance; locate the image, identify it as real or virtual, and calculate its magnification.
- Locate the image of objects placed in front of spherical mirrors.
- Locate and describe the final images of objects placed in front of optical systems consisting of one or two lenses.
- Calculate the change in magnification as distance between lenses is changed.
- Use ray tracing to explain image formation by spherical mirrors and thin lenses.
- Relate far- and near point to description of the human eye in terms of a single lens.
- Determine the prescription of near- and far-sighted person using eyeglasses and contact lenses.
- Calculate the size of a feature on an object that can be observed with a person with his/her naked eyes and a telescope.
- Predict the total number of maxima obtained when light of a specific wavelength is incident on a diffraction grating.
- Explain the red- and blue shift of the electromagnetic spectrum in terms of the Doppler effect.

Optional Components

5. Special Relativity:

The successful Algebra-Based Physics II (with lab) student will be able to:

5a. Predict the relative perception of a time interval [time dilation] or the length [Lorentz contraction] of an object for observers in different inertial reference frames using the Lorentz transformations.

5b. Apply the relativistic momentum-energy principle to objects moving at a speed close the speed of light.

Sample tasks

- Relate the key result of the Michelson-Morley experiment to the postulates of special relativity.
- Determine the observed length of an spaceship traveling past an observer on Earth at a relative speed near the speed of light and compare this to the length of the spaceship in the reference frame of the crew.
- Resolve the so-called "twin paradox" of special relativity.
- Calculate the kinetic energy and momentum of a proton accelerated to a speed near *c* and compare these values to their Newtonian counterparts.
- Explain and predict the dynamics of objects moving at high, constant speeds in terms of the principles of special relativity.

6. Quantum Physics:

The successful Algebra-Based Physics II (with lab) student will be able to:

6a. Differentiate between wave- and particle-like properties of light and relate them to each other.

6b. Describe the production and properties of photoelectrons with the particle-like property of light.
6c. Relate the intensity of light (EM waves) in terms of the number and frequency of photons.
6d. Determine if the condition under which wave-like properties of particles are relevant.
6e. Relate the wave-like nature of an electrons in its stationary state to the size of a confining potential [particle in a box].
6f. Relate the outcome of the Rutherford experiment to the atomic model.
6g. Determine the resolving power of an electron microscope with the Heisenberg uncertainty principle.
6h. discuss the scattering of a photon off an electron (Compton effect).
6i. Discuss the spontaneous and stimulated emission of light (photons); explain the basic principle underlying a laser.
6j. discuss qualitatively the quantum-mechanical picture of the hydrogen atom.

Sample tasks

- Relate the intensity of light (EM waves) in terms of the number and frequency of photons.
- Calculate the longest wavelength of light that can eject electrons from a metal with a known work function.
- Find the wavelength of an electron with a specified momentum or a specified kinetic energy (for speeds well below the speed of light).
- Calculate the energy and frequency of the photon emitted as atomic hydrogen makes a transition from n_i *to* n_f.
- Determine the series (Lyman, Balmer, Paschen, ... (or basically determine n_f)) for a set of hydrogen spectral lines given the frequencies or wavelengths of the set.
- Calculate the wavelength of a thermal neutron.
- Estimate the mass of a particle which only exists long enough to travel across the nucleus of a typical atom at approximately the speed of light.

7 Nuclear Physics:

The successful Algebra-Based Physics II (with lab) student will be able to:

7a. Compare the size of atoms and nuclei and the forces between the particles composing them.
7b. Calculate the binding energy per nucleon from mass-defect of atoms.
7c. Recognize the variation in nuclear stability at low and high Z.
7d. Distinguish between fission and fusion in nuclear reactions and explain how energy is "released."
7e. Describe the initial and final isotopes involved in alpha, beta, and gamma decay.
7f. Describe radioactive decay and activity in terms of half-life and initial number of radioactive isotopes.

Sample tasks

- Describe how properties of nuclei reflect properties of the Coulomb- and strong nuclear force.
- Compare the mass of a nucleus to the masses of its components (protons and neutrons) and calculate the binding energy per nucleon.
- Predict the energy yield or particle products of a nuclear reaction.
- Explain why the number of neutrons exceeds the number of protons in high-Z nuclei.
- Characterize the "valley of stability" of nuclei.

- Given a nucleus explain how to determine if the nucleus is stable with respect to a specified decay mode, e.g., alpha decay.
- Describe alpha- and beta-decay as a trajectory towards the valley of stability in a *N-vs-Z* plot.
- Describe how fission of large nuclei and fusion of small nuclei can release energy.
- Identify the types of particles emitted in beta decay.
- Describe beta decays as a transformation of protons into neutrons and vice versa.
- Predict the number of protons remaining when a nucleus with Z protons ejects an alpha particle.
- Calculate the age of a radioactive sample from its activity and half-life.
- Qualitatively explain biological effects of ionizing radiation.